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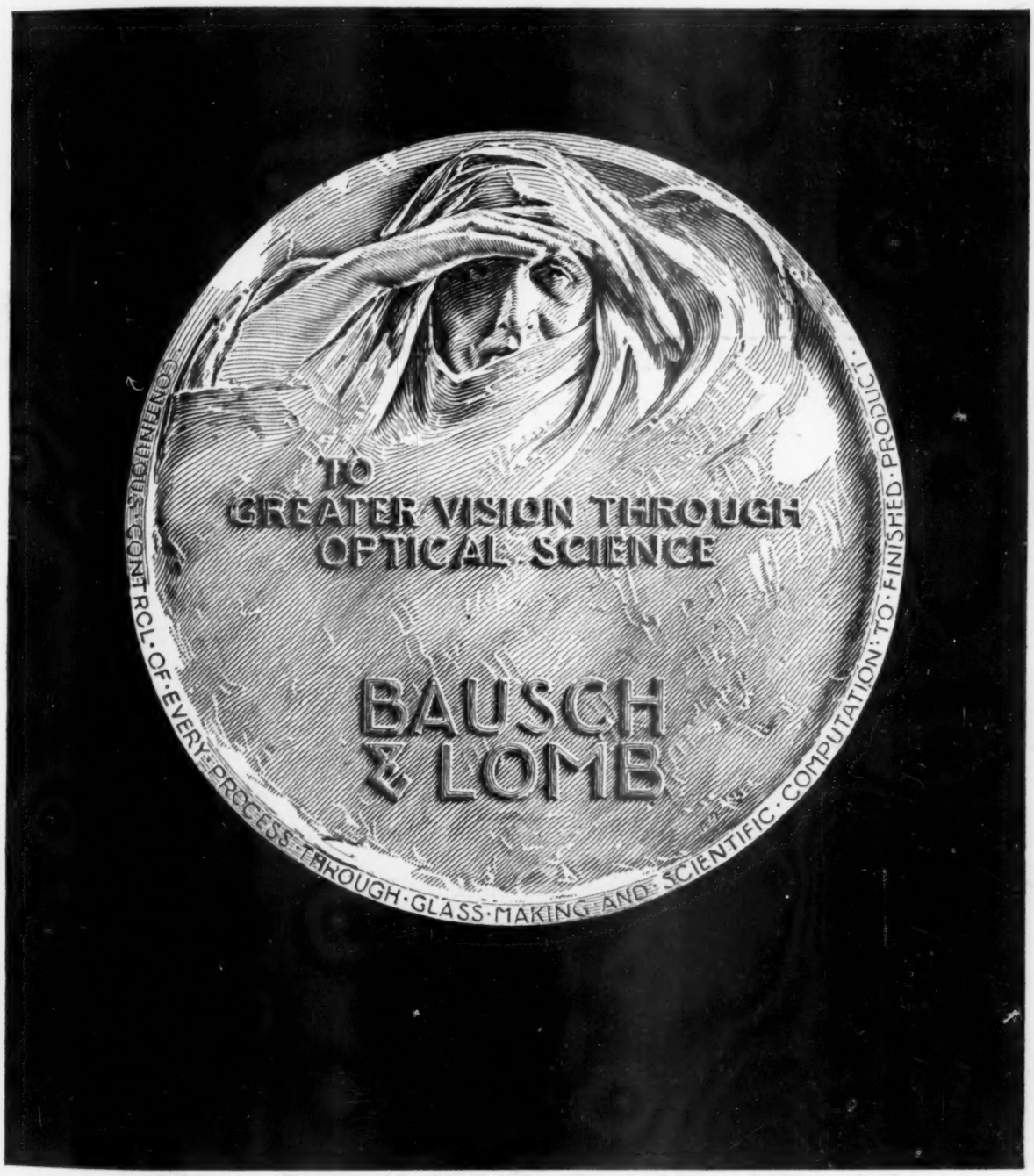

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FRIDAY, NOVEMBER 21, 1919

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ATOMIC PROJECTILES AND THEIR COLLISIONS WITH LIGHT ATOMS[1]

THE discovery of radio-activity has not only thrown a flood of light on the processes of transformation of radio-active atoms; it has at the same time provided us with the most powerful natural agencies for probing the inner structure of the atoms of all the elements. The swift α-particles and the high-speed electrons or β-rays ejected from radio-active bodies are by far the most concentrated sources of energy known to science. The enormous energy of the flying α-particle or helium atom is illustrated by the bright flash of light it produces when it impacts on a crystal of zinc sulphide, and by the dense distribution of ions along its trail through a gas. This great store of energy is due to the rapidity of its motion, which in the case of the α-particle from radium C (range 7 cm. in air) amounts to 19,000 km. per second, or about 20,000 times the speed of a rifle-bullet. It is easily calculated that the energy of motion of an ounce of helium moving with the speed of the α-particle from radium C is equivalent to 10,000 tons of solid shot projected with a velocity of 1 km. per second.

In consequence of its great energy of motion the charged particle is able to penetrate deeply into the structure of all atoms before it is deflected or turned back, and from a study of the deflection of the path of the α-particle we are able to obtain important evidence on the strength and distribution of the electric fields near the center or nucleus of the atom.

Since it is believed that the atom of matter is, in general, complex, consisting of positively and negatively charged parts, it is to be anticipated that a narrow pencil of α-particles, after passing through a thin plate of matter, should

[1] An address before the Royal Institution of Great Britain, June 6, 1919.

be scattered into a comparatively broad beam. Geiger and Marsden showed not only that much small scattering occurred, but also that in passing through the atoms of a heavy element some of the α-particles were actually turned back in their path. Considering the great energy of motion of the α-particle, this is an arresting fact, showing that the α-particle must encounter very intense forces in penetrating the structure of the atom. In order to explain such results, the idea of the nucleus atom was developed in which the main mass of the atom is concentrated in a positively charged nucleus of very small dimensions compared with the space occupied by the electrons which surround it. The scattering of α-particles through large angles was shown to be the result of a single collision where the α-particle passed close to this charged nucleus. From a study of the distribution of the particles scattered at different angles, results of first importance emerged. It was found that the results could be explained only if the electric forces between the α-particle and charged nucleus followed the law of inverse squares for distances apart of the order of 10^{-11} cm. Darwin pointed out that the variation of scattering with velocity was explicable only on the same law. This is an important step, for it affords an experimental proof that, at any rate to a first approximation, the ordinary law of force holds for electrified bodies at such exceedingly minute distances. It was also found that a resultant charge on the nucleus measured in fundamental units was about equal to the atomic number of the element. In the case of gold this number is believed from the work of Moseley to be 79.

Knowing the mass of the impinging α-particle and of the atom with which it collides, we can determine from direct mechanical principles the distribution of velocities after the collision, assuming that there is no loss of energy due to radiation or other causes. It is important to notice that in such a calculation we need make no assumption as to the nature of the atoms or of the forces involved in the approach and separation of the atoms. For example, if an α-particle collides with another helium atom, we should expect the α-particle to give its energy to the helium atom, which could thus travel on with the speed of the α-particle. If an α-particle collides directly with a heavy atom—*e. g.*, of gold of atomic weight 197—the α-particle should retrace its path with only slightly diminished velocity, while the gold atom moves onward in the original direction of the α-particle, but with about one fiftieth of its velocity. Next, consider the important case where the α-particle of mass 4 makes a direct collision with a hydrogen atom of mass 1. From the laws of impact, the hydrogen atom is shot forward with a velocity 1.6 times that of the direction, but with only 0.6 of its initial speed. Marsden showed that swift hydrogen atoms set in motion by impact with α-particles can be detected like α-particles by the scintillations produced in a zinc sulphide crystal. Recently I have been able to measure the speed of such H atoms and found it to be in good accord with the calculated value, so that we may conclude that the ordinary laws of impact may be applied with confidence in such cases. The relative velocities of the α-particles and recoil atom after collision can thus be simply illustrated by impact of two perfectly elastic balls of masses proportional to the masses of the atoms.

While the velocities of the recoil atoms can be easily calculated, the distance which they travel before being brought to rest depends on both the mass and the charge carried by the recoil atom. Experiment shows that the range of H atoms, like the range of α-particles, varies nearly as the cube of their initial velocity. If the H atom carries a single charge, Darwin showed that its range should be about four times the range of the α-particle. This has been confirmed by experiment. Generally, it can be shown that the range of a charged atom carrying a single charge is mu^3R, where m is the atomic weight, and u the ratio of the velocity of the recoil atom to that of the α-particle, and R the range of the α-particle before collision. In comparison of theory with experiment, the results agree better if the index is taken as 2.9 instead of 3. If, however, the

recoil atom carries a double charge after a collision, it is to be expected that its range would only be about one quarter of the corresponding range if it carried a single charge. It follows that we can not expect to detect the presence of any recoil atom carrying two charges beyond the range of the α-particle, but we can calculate that any recoil atom, of mass not greater than oxygen and carrying a single charge, should be detected beyond the range of the α-particle. For example, for a single charge the recoil atoms of hydrogen and helium should travel 4 R, lithium 2.8 R, carbon 1.6 R, nitrogen 1.3 R, and oxygen 1.1 R, where R is the range of the incident α-particles. We thus see that it should be possible to detect the presence of such singly charged atoms, if they exist, after completely stopping the α-particles by a suitable thickness of absorbing material. This is a great advantage, for the number of such swift recoil atoms is minute in comparison with the number of α-particles, and we could not hope to detect them in the presence of the much more numerous α-particles.

In order to calculate the number of recoil atoms scattered through any given angle from the direction of flight of the α-particles, it is necessary, in addition, to make assumptions as to the constitution of the atoms and as to the nature and magnitude of the forces involved in the collision. Consider, for example, the case of a collision of an α-particle with an atom of gold of nuclear charge 79. Assuming that the nucleus of the α-particle and that of the gold atom behave like point charges, repelling according to the inverse square law, it can readily be calculated that, for direct collision, the α-particles from radium C, which is turned through an angle of 180°, approaches within a distance $D = 3.6 \times 10^{-12}$ cm. of the center of the gold nucleus. This is the closest possible distance of approach of the α-particle, and the distance increases for oblique collisions. For example, when the α-particle is scattered through an angle of 150°, 90°, 30°, 10°, 5°, the closest distances of approach are 1.01, 1.2, 2.4, 6.2, 12 D respectively.

In the experiments of Geiger and Marsden, the number of α-particles scattered through 5° was observed to be about 200,000 times greater than the number through 150°. The variation with angle was in close accord with the theory, showing that the law of inverse squares holds for distances between 3.6×10^{-12} cm. and 4.3×10^{-11} cm. in the case of the gold atom. The experiments of Crowther in 1910 on the variation of scattering of β-rays with velocity indicate that a similar law holds also in that case, and for even greater distances from the nucleus.

We have seen that Marsden was able by the scintillation method to detect hydrogen atoms set in swift motion by α-particles up to distances about four times the range of the incident α-particle. In Marsden's experiments a thin-walled glass tube filled with radium emanation served as an intense source of rays. Since the lack of homogeneity of the α-radiation and the absorption in the glass are great drawbacks in making an accurate study of the laws controlling the production of swift atoms by impact, I have found it best to use for the purpose a homogeneous source of radium C by exposing a disc in a strong source of emanation. Fifteen minutes after removal from the emanation the α-rays from the disc are practically homogeneous, with a range in air of 7 cm. By special arrangements very intense sources of α-radiation can be produced in this way, and in the various experiments discs have been used the γ-ray activity of which has varied between 5 to 80 milligrams of radium. Allowance can easily be made for the decay of the radiation with time.

In the experiments with hydrogen the source was placed in a metal box about 3 cm. away from an opening in the end covered by a thin sheet of metal of sufficient thickness to absorb the α-rays completely. A zinc sulphide screen was mounted outside about 1 mm. away from the opening, so as to allow for the insertion of absorbing screens of aluminium or mica. The apparatus was filled with dry hydrogen at atmospheric pressure. The H atoms striking the zinc sulphide screen were counted by means of a microscope in the

usual way. The strong luminosity due to the β-rays from radium C was largely reduced by placing the apparatus in a powerful magnetic field which bent them away from the screen.

If we suppose, for the distances involved in a collision, that the α-particle and hydrogen nucleus may be regarded as point charges, it is easy to see that oblique impacts should occur much oftener than head-on collisions, and consequently that the stream of H atoms set in motion by collisions should contain atoms the velocities of which vary from zero to the maximum produced in a direct collision. The slow-velocity atoms should greatly preponderate, and the number of scintillations observed should fall off rapidly when absorbing screens are placed in the path of the rays close to the zinc sulphide screen.

A surprising effect was, however, observed. Using α-rays of range 7 cm., the number of H atoms remained unchanged when the absorption in their path was increased from 9 cm. to 19 cm. of air equivalent. After 19 cm. the number fell off steadily, and no scintillations could be observed beyond 28 cm. air absorption. In fact, the stream of H atoms resembled closely a homogeneous beam of α-rays of range 28 cm., for it is well known that, owing to scattering, the number of α-particles from a homogeneous source begin to fall off some distance from the end of their range. The results showed that the H atoms are projected forward mainly in the direction of the α-particles and over a narrow range of velocity, and that few, if any, lower velocity atoms are present in the stream.

If we reduce the velocity of the α-particle by placing a metal screen over the source, it is found that the distribution of H atoms with velocity changes, and that the rays are no longer nearly homogeneous. When the range of the α-rays is reduced to 3·5 cm., the absorption of the H atoms is in close accord with the value to be expected from the theory of point charges. It is clear, therefore, that the distribution of velocity among the H atoms varies with the speed of the incident α-particles, and this indicates that a marked change takes place in the distribution and magnitude of the forces involved in the collision when the nuclei approach closer than a certain distance.

In addition to these peculiarities, the number of H atoms is greatly in excess of the number to be expected on the simple theory. For example, for the swiftest α-rays the number which is able to travel a distance equivalent to 10 cm. of air is more than thirty times greater than the calculated value. The variation in number of H atoms with velocity of the incident α-particle is also entirely different from that to be expected on the theory of point charges. The number diminishes rapidly with velocity, and is very small for α-particles of range 2·5 cm.

It must be borne in mind that the production of a high-speed H atom by an α-particle is an exceedingly rare occurrence. Under the conditions of the experiment the number of H atoms is seldom more than 1/30,000 of the number of α-particles. Probably each α-particle passes through the structure of 10,000 hydrogen molecules in traversing one centimeter of hydrogen at atmospheric pressure, and only one α-particle in 100,000 of these produces a high-speed H atom; so that in 10^9 collisions with the molecules of hydrogen the α-particle, on the average, approaches only once close enough to the center of the nucleus to give rise to a swift hydrogen atom.

We should anticipate that for such collisions the α-particle is unable to distinguish between the hydrogen atom and the hydrogen molecule, and that H atoms should be liberated from matter containing free or combined hydrogen. This is fully borne out by experiment.

From the number of H atoms observed it can be easily calculated that the α-particle must be fired within a perpendicular distance of $2{\cdot}4 \times 10^{-13}$ cm. of the center of the H nucleus in order to set it in swift motion. This is a distance less than the diameter of the electron, viz. $3{\cdot}6 \times 10^{-13}$ cm. The general results obtained with α-rays of range 7 cm. are similar to those to be expected if the α-particle behaves like a charged disc, of radius of about the diameter of an electron,

travelling with its plane perpendicular to the direction of motion.

It is clear from the experiments with hydrogen that, for distances of the order of the diameter of the electron, the α-particle no longer behaves like a point charge, but that the α-particles must have dimensions of the order of that of the electron. The closest distance of approach in these collisions in hydrogen is about one tenth the corresponding distances in the case of a collision of an α-particle with an atom of gold.

The results obtained with hydrogen in no way invalidate the nucleus theory as used to explain the scattering of α-rays by heavy atoms, but show, as we should expect, that the theory breaks down when we approach very close to the nucleus structure. In our ignorance of the constitution of the nucleus of the α-particle, we can only speculate as to its structure and the distribution of forces very close to it. If we take the α-particles of mass 4 to consist of four positively charged H nuclei and two negative electrons, we should expect it to have dimensions of the order of the diameter of the electron, supposing, as seems probable, that the H nucleus is of much smaller dimensions than the electron itself. When we consider the enormous magnitude of the forces between the α-particle and the H nucleus in a close collision—amounting to 6 kg. of weight—it is to be expected that the structure of the α-particle should be much deformed, and that the law of force may undergo very marked changes in direction and magnitude for small changes in the closeness of approach of the two colliding nuclei. Such considerations offer a reasonable explanation of the anomalies shown in the number and distribution with velocity of the H atoms exhibited for different velocities of the α-particles.

When we consider the enormous forces between the nuclei, it is not so much a matter of surprise that the nuclei should be deformed as that the structure of the α-particle or helium nucleus escapes disruption into its constituent parts. Such an effect has been carefully looked for, but so far no definite evidence of such a disintegration has been observed. If this be the case, the helium nucleus must be a very stable structure to stand the strain of the gigantic forces involved in a close collision.

We have seen that the recoil atoms of all elements of atomic mass less than 18 should travel beyond the range of the α-particle, provided they carry a single charge. Preliminary experiments, in which the α-particles passed through pure helium, showed that no long-range recoil atoms were present, indicating that after recoil the helium atom carries a double charge. In a similar way no certain evidence has been obtained of long-range recoil atoms from lithium, boron, or beryllium. It is difficult in experiments with solids or solid compounds to be sure of the absence of hydrogen or water-vapor, which results in the production of numerous swift H atoms. These difficulties are not present in the case of nitrogen and oxygen, and a special examination has been made of recoil atoms in these gases. Bright scintillations were observed in both these gases about 2 cm. beyond the range of the α-particle. These scintillations are, presumably, due to swift N and O atoms carrying a single charge, for the ranges observed are about those to be expected for such atoms. The scintillations due to recoil atoms of N and O are much brighter than H scintillations, although the actual energy of the flying atom is greater in the later case. This difference in brightness is probably connected with the much weaker ionization per unit of path due to the swifter H atom.

The corresponding range of the recoil atoms was about the same in oxygen, nitrogen and carbon dioxide. Theoretically, it is to be anticipated that the N recoil atom should give a somewhat greater range than the O atom. The recoil atoms observed in carbon dioxide are apparently due to oxygen, for if the carbon atoms carried a single charge they should be detected beyond the range of O atoms.

The number of recoil atoms in nitrogen and oxygen and their absorption indicate that these atoms, like H atoms, are shot forward mainly in the direction of the α-particles. It

is clear from the results that the nuclei of the atoms under consideration can not be regarded as point charges for distances of the order of the diameter of the electron. Taking into account the close similarity of the effects produced in hydrogen and oxygen, and the greater repulsive forces between the nuclei in the later case, it seems probable that the abnormal forces in the case of oxygen manifest themselves at about twice the distance observed in the case of hydrogen, *i. e.*, for distances less than 7×10^{-13} cm. Such a conclusion is to be anticipated on general grounds, for presumably the oxygen nucleus is more complex and has larger dimensions than that of helium.

In his preliminary experiments Marsden observed that the active source always gives rise to a number of scintillations on a zinc sulphide screen far beyond the range of the α-particle. I have always found these natural scintillations present at the sources of radiation employed. The swift atoms producing these scintillations are deflected in a magnetic field, and have about the same range and energy as the swift H atoms produced by the passage of α-particles through hydrogen. The number of these natural scintillations is usually small, and it is very difficult to decide definitely whether such atoms arise from the disintegration of the active matter or are due to the action of the α-particles on hydrogen occluded in the source.

These natural scintillations were studied by placing the source in a closed box exhausted of air about 3 cm. from an opening in the end covered by a sheet of silver of sufficient thickness to stop the α-rays completely. The zinc sulphide screen was fixed outside close to the silver plate. On introducing dried oxygen or carbon dioxide into the vessel, the number of scintillations fell off in amount corresponding with the stopping power of the column of gas. An unexpected effect was, however, noticed on introducing dried air from the room. Instead of diminishing, the number of scintillations was increased, and for an absorption equivalent to 19 cm. of air the number was about twice that observed when the air was exhausted. It was clear from the results that the α-particles in their passage through air gave rise to long-range scintillations which appeared of about the same brightness as H scintillations. This effect in air was traced to the presence of nitrogen, for it was shown in dry, chemically prepared nitrogen as well as in air. The number of scintillations was much too large to be accounted for by the presence of traces of hydrogen or water-vapor, for the effect observed was equivalent to the number of H atoms produced by the mixture of hydrogen at 6 cm. pressure with oxygen. The measurements were always made well outside the range of the recoil nitrogen and oxygen atoms, which we have seen are stopped by 9 cm. of air.

These swift atoms which arise from nitrogen have about the same brightness and range as the H atoms produced from hydrogen, and, presumably, are charged hydrogen atoms. Definite information on this point should be obtained by measuring the deflection of a pencil of these atoms in a magnetic and electric field. The experiments are, however, exceedingly difficult on account of the very small number of the scintillations to be expected under the experimental conditions. It should be mentioned that the evidence so far obtained is not sufficient to distinguish definitely whether these are H atoms or atoms of mass 2, 3, or 4, for the range and brightness of the latter would not be very different from those shown by the H atom.

It is difficult to avoid the conclusion that these long-range atoms arising from the collision of α-particles with nitrogen are not nitrogen atoms, but probably charged atoms of hydrogen or atoms of mass 2. If this be the case, we must conclude that the nitrogen atom is disintegrated under the intense forces developed in a close collision with swift α-particles, and that the atom liberated formed a constituent part of the nitrogen nucleus. It may be significant that from radio-active data we should expect the nitrogen nucleus of atomic mass 14 to consist of three helium nuclei of mass 4, and either two hydrogen nuclei or one nucleus of mass 2.

The effect produced in nitrogen would be

accounted for if the H nuclei were outriders of the main nucleus of mass 12. The close approach of the α-particle leads to the disruption of its bond with the central nucleus, and under favorable conditions the H atom would acquire a high velocity and be shot forward like a free hydrogen atom. Taking into account the great energy of the particle, the close collision of an α-particle with a light atom seems to be the most likely agency to promote its disruption. Considering the enormous intensity of the forces brought into play in such collisions, it is not so much a matter of remark that the nitrogen atom should suffer disintegration as that the α-particle itself escapes disruption. The results, as a whole, suggest that if α-particles or similar projectiles of still greater energy were available for experiment, we might expect to break down the nucleus structure of many of the lighter atoms.

ERNEST RUTHERFORD

SECOND AWARD OF THE ELLIOT MEDAL

THE Elliot Medal is awarded annually by the National Academy of Sciences to the author of the leading publication of the year in zoology or paleontology. The first award was made for the year 1917 to Frank M. Chapman for his volume "The Distribution of Bird-Life in Columbia," published by The American Museum of Natural History. The second award for the year 1918 was to William Beebe, of the New York Zoological Society, on the completion of the first volume of his work on the "Pheasants."

In presenting Mr. Beebe to the Academy for the award, Professor Henry Fairfield Osborn made the following remarks:

Daniel Giraud Elliot, to whom the Academy is indebted for the Elliot Medal, was a leading ornithologist and mammalogist of the old school. He produced a series of splendid monographs on birds and mammals, and closed his scientific career with an exhaustive revision of the Primates. With the exception of a journey in Africa the greater part of his life was spent in museums, yet I believe if he were living he would not hesitate a moment to award the Elliot Medal for the Year 1918 to William Beebe on the completion of the first volume of his great work "A Monograph of the Pheasants."

This is a profound study of the living pheasants in their natural environment in various parts of eastern Asia. There are nineteen groups of these birds; eighteen were successfully hunted with the camera, with field-glasses, and when necessary for identification, with the shotgun. The journey occupied seventeen months, extended over twenty countries, and resulted in a rare abundance of material, both literary—concerning the life histories of birds—and pictorial, photographs and sketches. The journey extended over 52,000 miles; it ended in the great Museums of London, of Tring, of Paris, and of Berlin, for the purpose of studying the type collections. Thus the order of the work was from nature to the museum and to man, rather than from man and the museum to nature. It is this distinguished note of direct observation of natural processes, under natural conditions, which is needed to-day in biology to supplement the note of the laboratory and of experiment. Living birds and living mammals have as much to teach us in their natural surroundings as they taught Darwin and Wallace and we must endeavor to keep the eyes and minds of these great naturalists in our modes of vision.

The monograph covers the blood partridges, the tragopans, the impeyans, the gold and silver pheasants, the peacocks, the jungle fowl, and the history of the ancestry of our domestic fowls. It has important bearings on the Darwinian theories of protective coloration and of sexual selection, and on the De Vries theory of mutation. The full-grown male and female characters, the changes of plumage from chick to adult, the songs, courtships, battles, nests and eggs of nearly one hundred species are included and systematically described. The illustrations are by leading American and British artists. The haunts of the pheasants are shown in the author's photographs ranging from the slopes of the Himalayan snow-peaks, 16,000 feet

above the sea, to the tropical seashores of Java. Like Chapman's "Birds of Columbia," to which the Elliot Medal was awarded last year, this monograph puts the living bird, in its living environment, into the forefront.

It is for these reasons that the committee was unanimous, especially when its decision was confirmed without hesitation by Dr. J. A. Allen, the Nestor of American zoologists. It is not the magnificence of this monograph, not the superb illustrations, not the delightfully written text, but the truly Darwinian spirit which animated the author and which sustained him through seven years of continuous research and his arduous labors in the preparation of this monograph. When completed, we believe that it will come nearer to depicting the actually living forms of this great group than any book which has ever been written on a single family of birds.

PROPOSED CONSTITUTION AND BY-LAWS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

This copy of the Constitution and By-laws is the one presented to the Committee on Policy by the subcommittee on revision. It was adopted by the committee and presented to the association at the Baltimore meeting. It will be presented for adoption at the St. Louis meeting.

Edward L. Nichols,
Chairman of the Committee on Policy

CONSTITUTION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Article 1. Objects

The objects of the Association are to promote intercourse among those who are cultivating science in different parts of America, to cooperate with other scientific societies and institutions, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

Article 2. Membership

Persons willing to cooperate in the work of the Association may be elected to be members by the Council. Members who are professionally engaged in scientific work or who have advanced science by research may be elected to be Fellows. The admission fee for members is five dollars; the annual dues are four dollars.[1] A member who pays at one time the sum of seventy-five dollars to the Association becomes a life member and is exempt from further dues. A person who gives one thousand dollars to the Association may be elected to be a sustaining member and is exempt from further dues.

Article 3. Officers

The officers of the Association shall be elected by ballot by the Council, and shall consist of a President, a Vice-president from each section, a Permanent Secretary, a General Secretary, a Treasurer and a Secretary of each section. The President and the Vice-presidents shall be elected for one year, the other officers for four years. The officers shall perform the usual duties of these offices under the direction of the Council.

Article 4. Council

The Council shall consist of the President, the Vice-presidents, the Permanent Secretary, the General Secretary, the Secretaries of the Sections, and the Treasurer, of one fellow elected by each affiliated society and one additional fellow from each affiliated society having more than one hundred members who are fellows of the Association, and of eight fellows, two elected annually by the Council for a term of four years. There shall be an Executive Committee of the Council, consisting of the President, the Permanent Secretary, the General Secretary, and eight members elected by the Council, two annually for a term of four years. The Council may appoint standing or temporary committees to make reports, to assist in the conduct of the work of the Association and to promote its objects.

Article 5. Sections

The Association shall be divided into the following Sections: A, *Mathematics;* B, *Physics;* C, *Chemistry;* D, *Astronomy;* E, *Geology and Geography;* F, *Zoological Sciences;* G, *Botanical Sciences;* H, *Anthropology and Archeology;* I, *Psychology and Philosophy;* J, *Social and Economic Sciences;* K, *Historical and Philological Sciences;* L, *Engineering;* M, *Medicine;* N, *Agriculture;* O,

[1] The Committee on Policy recommends that the annual dues be five dollars and the life membership fee one hundred dollars.

Manufactures and Commerce; P, *Education.* Members of the Association shall be members of that Section or of those Sections under which their work or their interests fall. Members of the Section shall nominate to the Council a Chairman, who becomes *ex officio* a Vice-president of the Association and whose term of office shall be one year, and a Secretary, whose term of office shall be four years. These officers, together with four fellows, one elected annually by the Section for a term of four years, and the representatives on the Council of affiliated societies in the same field shall form a Sectional Committee. This committee shall arrange the scientific programs of the meetings and may form sub-sections or hold joint meetings with other sections or other societies. It may appoint committees and shall in all ways promote the objects of the Association within its own field.

Article 6. Divisions and Branches

Regional Divisions and Local Branches of the Association may be formed by vote of the Council. Such Divisions and Branches may elect officers, hold meetings, appoint committees, enter into relations with other societies and promote within their fields the objects of the Association.

Article 7. Associated and Affiliated Societies

National and local scientific societies may, by vote of the Council, become associated with the Association. Those Associated Societies which the Council shall designate as Affiliated Societies shall be represented on the Council and on the Sectional Committees as provided in Articles 4 and 5.

Article 8. Meetings

The Association shall hold an annual meeting at such time and place as may be determined by the Council. Other meetings of the Association and of the Sections may be authorized by the Council. The Divisions and the Branches may hold annual and other meetings.

Article 9. Proceedings

The Proceedings of the Association and the list of officers and members shall be published in such manner as the Council may direct.

Article 10. Funds

The Permanent Secretary shall collect the annual dues and make expenditures as directed by the Council. The Treasurer shall deposit or invest the permanent funds of the Association, as provided for trust funds by the laws of the state of Massachusetts or the state of New York. Bequests and gifts will be administered in accordance with the provisions of the donors. The payments from sustaining and life members form part of the permanent fund, and the income (after the death of the member) shall be used for research, unless otherwise directed by unanimous vote of the Council or by a majority vote at two consecutive annual meetings.

Article 11. Alteration of the Constitution

This Constitution may be amended at a General Session by unanimous vote or by a majority vote at two consecutive annual meetings.

BY-LAWS AND RULES OF PROCEDURE

I

The Association is American, its field covering North, Central and South America. Inhabitants of any country are eligible to membership.

II

1. An incorporated scientific society or institution or a public or incorporated library may become a member by vote of the Council.

2. Associates on payment of four dollars may be admitted to the privileges of a meeting, except voting.

3. Foreign associates may be admitted without fee to the privileges of a meeting, except voting.

4. All members who are professionally engaged in scientific work, or who have advanced science by research, may be elected by the Council to be fellows on nomination or on their own application. This qualification is understood to have been met by members of affiliated societies having a research qualification.

5. The Council may exclude from the Association any one who has made improper use of his membership or whose membership is regarded as detrimental to the Association.

III

1. The Permanent Secretary, the General Secretary and Treasurer of the Association and the Secretaries of the Sections shall be elected at the larger convocation week meetings held once in four years beginning the last week of the year 1916. Vacancies in these offices shall be filled by the Council.

2. The President of the Association shall give an address at a general session of the Association at the annual meeting following that over which he presided.

3. The Vice-presidents shall hold seniority in the order of their continuous membership in the Association.

4. The Permanent Secretary shall attend to the business of the Association, the arrangements for the meetings and such other matters as the Council may designate. He may employ, with the approval of the Council, an Assistant Secretary. The salaries of the Secretaries shall be determined by the Council.

5. The General Secretary shall attend to matters connected with the organization of the Association, its relations to the affiliated societies and such other matters as the Council may designate. He shall receive such compensation as may be determined by the Council.

6. The Permanent Secretary, the General Secretary and the Treasurer shall present annually to the Council an account of the funds in their charge. These accounts shall be audited by an Auditor elected by the Council. There shall be a Finance Committee of three, elected by the Council, including the Treasurer, who shall give advice in regard to the investment of the funds of the Association. The Treasurer and the Permanent Secretary and General Secretary shall present a budget to the Council for the year following the annual meeting.

IV

1. There shall be a Committee on Grants, appointed by the President, with the advice of the Council, consisting of eight members, two appointed annually for a period of four years, which shall award for scientific research such part of the income from the permanent and special funds of the Association as may be appropriated for that purpose by the Council.

2. The following standing committees are authorized: Committee of One Hundred on Scientific Research; Committee of One Hundred on National Health; Committee on Delegates from Educational and Scientific Institutions; Committee on Expert Testimony; Committee on the Jane M. Smith Life Membership Fund.

3. A local committee shall be organized by the members resident in the place where a meeting of the Association is held. This committee may appoint an executive committee and other committees and shall make arrangements for the meeting, in cooperation with the Permanent Secretary and the other officers of the Association.

V

1. The Sectional Committees shall arrange for each annual meeting a program of general scientific interest, occupying usually one or two sessions. The Section shall not hold sessions for the reading of special papers when the affiliated society in the same field meets with the association.

2. No member shall take part in the organization or hold office in more than one section at any one meeting.

VI

1. A Pacific Division has been organized whose territory lies west of the "Rocky" Mountains. This Division and other Divisions that may be authorized by the Council have full control of their meetings, their affiliations with other scientific organizations, and of all movements to promote the advancement and diffusion of science in their territory. The Pacific Division shall be allowed for its expenses the entrance fees collected through its efforts and one dollar a year for each member in good standing.

2. Local Branches may be formed by members residing in the same locality. These branches shall be allowed for their expenses the entrance fees collected through their efforts and an amount for their expenses not to exceed fifty cents for each member in good standing.

VII

1. Affiliated societies having two representatives on the Council and on the Sectional Committees are:

2. Affiliated societies having one representative on the Council and on the Sectional Committees are:

3. Associated societies are:

VIII

1. A general session of the Association shall usually be held on the first evening of the meeting and at this session the address of the retiring president shall be given. Other general sessions may be arranged by the Council.

2. The Council shall ordinarily meet on the afternoon of the first day of the meeting. It may also meet at such other times as may be decided, and shall ordinarily hold a meeting in the spring at Washington.

3. The Sectional Committees shall ordinarily hold meetings on the morning of the first day of the annual meetings and may hold such other meetings as they may arrange.

4. The Executive Committee shall meet on the day preceding the annual meeting and at such other times during the meeting as it may decide. It shall ordinarily hold meetings in the spring and in the autumn.

IX

1. By arrangement with the publishers of SCIENCE this journal publishes the official notices and proceedings of the Association and is sent to all members in good standing, the sum of $2 being paid to the publishers of the journal for each member. Members may by request receive *The Scientific Monthly* in place of SCIENCE. This arrangement may be cancelled by the Council of the Association or by the publishers of the journal, after one year's notice has been given by either party.

X

1. The official year of the Association shall begin on October 1, and the dues of members are payable on that date. Only members who have paid their dues shall enjoy the privileges of the meetings and receive publications of the Association, but those not longer than two years in arrears for dues are retained on the membership list. Members dropped from membership for nonpayment of dues may have their names reinstated by payment of arrearages or may be reelected with payment of the entrance fee. In the case of members of affiliated societies elected to membership in the American Association for the Advancement of Science within one year of their election to membership in the affiliated society, the entrance fee shall be remitted.

2. The Secretaries of the Association and of the Sections shall be allowed $30 in lieu of their traveling expenses to the annual meeting, or, if their expenses are less than that sum, the amount of their expenses.

3. Members of the Executive Committee shall be allowed $30 in lieu of their traveling expenses in attendance on meetings of the Committee, held apart from the meetings of the Association, or, if their expenses are less than that sum, the amount of their expenses.

XI

These By-Laws and Rules of Procedure may be amended by vote of the Council.

SCIENTIFIC EVENTS

THE SOUTHWESTERN GEOLOGICAL SOCIETY

ON November 8, after several previous meetings, a number of the geologists of Dallas, Fort Worth, Austin, Shreveport, and other cities of the southwest organized an association, to be known as the Southwestern Geological Society. It is not the intention of the founders that the society shall be a competitor of either the Geological Society of America or the American Association of Petroleum Geologists, but that it shall be a regional organization comparable to the Cordilleran section of the Geological Society of America, the Geological Society of Washington, or other similar local organizations. It is also intended that it shall provide, through bi-monthly sectional meetings in each of the important cities of the southwest, frequent opportunities for the exchange of scientific data and views.

The promotion of fellowship and cooperation are the paramount aims, and publications, for the present, except of brief abstracts, will be a secondary consideration.

The membership will be drawn from those actively engaged in geology in the southwest, both academic and economic, and will include the professors of the state and other universities and members of the geological surveys, as well as those engaged in economic work.

The officers elected at the first meeting are as follows: President, Myron L. Fuller; vice-presidents, Wm. Kennedy and Wallace Pratt; secretary E. W. Shuler; treasures, R. B. Whitehead; council Robert T. Hill, H. P. Bybee, John A. Udden, W. E. Wrather and Chester A. Hamil.

Among the founder members were the following; Ellis W. Shuler, Myron L. Fuller, Robert T. Hill, F. W. Simonds, Wm. Kennedy, R. B. Whitehead, John A. Udden, F. A. Lahee, Wallace Pratt, F. L. Whitney, J. W. Beede, H. P. Bybee, E. B. Hopkins, C. A. Hamil, J. E. Brantly, V. V. Waite.

All geologists of good standing interested in the geology of the southwest are invited to send in their applications for membership to Dr. Ellis W. Shuler, secretary, Southern Methodist University, Dallas, Texas.

THE CHICAGO MEETING OF THE AMERICAN PHYSICAL SOCIETY

THE 100th regular meeting of the American Physical Society will be held in the Ryerson Physical Laboratory of the University of Chicago, on Friday and Saturday, November 28 and 29, 1919. The occasion will be

marked by a symposium of papers of unusual importance on the electron-tube, presented upon invitation of the president of the society. There will also be the usual program of papers contributed by members in general. The Central Association of Science and Mathematics Teachers holds it annual meeting on the same dates, and arrangements are being made for the usual joint session.

The provisional program of special papers which will probably be given on Saturday morning, is as follows:

"Phenomena in pure-tungsten filament electron tubes," Irving Langmuir, The General Electric Company.

"Phenomena in oxide-coated filament tubes," H. B. Arnold, The Western Electric Company.

"The relations of the constants of an electron tube to its physical dimensions," L. A. Hazeltine, Stevens Institute of Technology.

"Theory of action of electron tubes as amplifiers," John M. Miller, Bureau of Standards.

"Theory of action of electron tubes as generators," John H. Morecroft, Columbia University.

"High power transmission sets," W. C. White, The General Electric Company.

"Telephone sets," O. B. Blackwell, American Telephone and Telegraph Company.

Members wishing to present papers at the Chicago meeting are requested to send abstracts ready for publication, to the secretary, before November 15. The secretary expects to send the program to all members before the meeting, but the delays in the mails are so great at present that members should not depend upon the program to determine their attendance.

The next following meeting of the society will be held in St. Louis in the week of December 29-January 3. Members are requested to submit abstracts of papers for this meeting at the earliest possible date, not waiting for further notice.

Dayton C. Miller,
Secretary

Case School of Applied Science,
Cleveland, Ohio

THE HISTORY OF SCIENCE AND THE AMERICAN HISTORICAL ASSOCIATION

The readers of Science may be interested to learn that at the coming annual meeting of the American Historical Association a conference will be devoted to the history of science. This is the first time that such a conference has been held, and it is earnestly hoped that many of those who are interested in this promising field may attend the session, whether they are members of the American Historical Association or not. The program, as thus far arranged, comprises papers on the History of Egyptian Medicine by Thomas Wingate Todd, professor of anatomy, Western Reserve University; on the History of Algebra by Louis C. Karpinski, professor of mathematics, University of Michigan; on Peter of Abano, a Medieval Scientist, by Lynn Thorndike, professor of history, Western Reserve University; and on The Problem of the History of Science in the College Curriculum, by Henry Crew, professor of physics, Northwestern University. The conference will take place in the Hollenden Hotel, Cleveland, Ohio, at 10 A.M., Wednesday morning, December 31.

Elbert J. Benton

THE SECTION OF ZOOLOGY OF THE AMERICAN ASSOCIATION

The Convocation Week meetings of Section F (Zoology) of The American Association for the Advancement of Science will be held in conjunction with those of the American Society of Zoologists at Washington University, St. Louis, Mo., on December 29, 30 and 31, 1919. As the officers of the American Society of Zoologists are responsible for the program under the rules of the American Association all titles and abstracts of papers should be sent to Professor W. C Allee, Lake Forest, Illinois. They should be in his hands before December 9. The address of the retiring vice-president of Section F, Professor William Patten, will be given at the annual dinner on Wednesday evening, December 31. The subject of the address will be "The message of the biologist." H. V. Neal,
Secretary of Section F

Tufts College, Mass.

THE DEFLECTION OF LIGHT BY GRAVITATION AND THE THEORY OF RELATIVITY

A joint meeting of the Royal Society and the Royal Astronomical Society was held on

November 6, for the discussion of observations made during the total solar eclipse of May 29 last. Sir Frank Dyson, the astronomer royal, opened the discussion, and was followed by Professor Eddington and other members of the eclipse expedition. Cablegrams to the daily papers report that the photographic plates show the deflection of the rays of light from the stars by the sun's gravitation that the Einstein theory of relativity requires. A similar attempt was made by the Crocker Expedition of the Lick Observatory in 1918, and the problem is described by Dr. W. W. Campbell, the director of the observatory, in SCIENCE for July 12, 1918. An article on relativity in physics by Professor Reinhard A. Wetzel, of the College of the City of New York, is printed in SCIENCE for October 3, 1913, and one by Professor William Marshall, of Purdue University, in *The Popular Science Monthly* for May, 1914. The article on the ether drift by Professor A. A. Michelson and Professor Edward W. Morley, which gave rise to the discussion, was printed in *The American Journal of Science* in 1887. Albert Einstein, then an employee in the patent office at Bern, first published his theory of relativity in the *Annalen der Physik* in 1905. Dr. Einstein later became professor in the Zurich Polytechnic School and was called to Berlin several years ago.

SCIENTIFIC NOTES AND NEWS

THE Nobel prize for physics for 1918 has been awarded to Professor Max Planck, of Berlin, and for 1919 to Professor Stark, of Greifswald. The prize for chemistry for 1918 has been awarded to Professor Fritz Haber, of Berlin.

THE National Academy of Sciences has voted to confer its Public Welfare medal on Mr. Herbert Hoover.

SURGEON-GENERAL WILLIAM C. BRAISTED, of the U. S. Navy Medical Corps, has been elected an honorary fellow of the Royal College of Surgeons of Edinburgh.

DR. M. C. TANQUARY, associate professor of entomology at the Kansas State Agricultural College, has resigned to accept the position of state entomologist of Texas, and chief of the division of entomology of the Texas Agricultural College. His resignation takes effect on February 1.

G. B. RICHARDSON has been placed in direct charge of the oil and gas section of the U. S. Geological Survey.

DR. G. DALLAS HANNA, who for eight years has been an assistant in the United States Bureau of Fisheries, has been appointed curator of invertebrate paleontology in the California Academy of Sciences. Dr. Hanna has for seven seasons been engaged in scientific work on the Pribilof Islands, Alaska, having taken the census of the fur seal herd for five consecutive years. He brings to the museum of the academy his collection of mollusks which numbers about 100,000 specimens.

SIR HENRY ALEXANDER MIERS, F.R.S., vice-chancellor of the University of Manchester, has been appointed a member of the advisory council to the committee of the privy council for scientific and industrial research.

AT the annual meeting of the Royal College of Physicians of Ireland, held on October 18, Dr. James Craig, professor of practise of medicine in Trinity College, Dublin, was elected president.

V. K. TING, director of the Geological Survey of China, is travelling in the United States.

PROFESSOR LYNDS JONES, of the department of zoology, of Oberlin College, conducted a party of students of ecology on a trip to the Pacific coast during the summer. The entire journey was made in automobiles—four Ford cars, a Franklin sedan, and a trailer. The route followed the Trans-continental, the Union Pacific and Northeastern to Omaha, thence to Yellowstone Park, spending several days in the park, up the Columbia River through eastern Oregon to Portland, then to Moclips, Washington, where camp was made and the party explored the coast and the neighboring islands. Except for occasional hospitality of friends along the way, every night was spent out of doors, and meals were

prepared over camp fire. Study was made while traveling of the animals, birds and plants, the nature of the country and the character of the soil, and lectures were given each day. The party left Oberlin on June 20 and returned on August 27 all in good health and reporting a most successful and enjoyable trip. For next summer a different trip is planned, through Colorado and Estes Park to California and the Yosemite.

It is stated in *Nature* that the Swedish Academy of Science has reported favorably on a request by Professor J. G. Andersson, formerly director of the Swedish Geological Survey, for a government grant of 90,000 kroner towards scientific researches and collections in China, where Dr. Andersson is now geological adviser to the Chinese government. It is hoped that the Swedish Riksmuseum will thus receive rich collections in paleontology, prehistory and zoology, but, to comply with conditions laid down by Professors Andersson and Witman, the fossil vertebrates will go to Upsala.

Dr. James R. Angell, on leave of absence as head of the department of psychology and dean of the faculties of the University of Chicago, now chairman of the National Research Council, recently visited the Carnegie Institute of Technology, Pittsburgh, and conferred with several members of the faculty who are particularly interested in the progress of research. In the afternoon, Dr. Angell addressed the faculty and graduate students of the division of applied psychology.

At the meeting of the Section on Medical History of the College of Physicians of Philadelphia, held on November 15, Lieutenant Colonel Fielding H. Garrison, M. C., U. S. Army, Washington, D. C., and Dr. Edward C. Streeter, Boston, presented a paper on "Sculpture and Paintings as Modes of Anatomical Expression."

The president, Professor James Ward, of Cambridge University, delivered the inaugural address before the Aristotelian Society on November 3 on the subject "In the beginning . . ." The congress which the society arranges annually will be held next year at Oxford in September, and the French Philosophical Society will take part.

A course of twelve Swiney lectures on "Geology and Mineral Resources of the British Possessions in Africa" will be given at the Imperial College of Science and Technology, London, by Dr. J. D. Falconer, on November 10 and later.

The tablets in memory of Lord Lister, executed for University College by Professor Harvard Thomas, were unveiled on November 11, by Sir George Makins, president of the Royal College of Surgeons, and Sir J. J. Thomson, president of the Royal Society. The Duke of Bedford, president of the Lister Memorial Committee, presided.

Dr. William G. Bissell, bacteriologist and sanitary expert, died on November 14, at the age of forty-nine years. He was director of the laboratories of the Buffalo Health Department for twenty-five years and past president of the New York State Sanitary Officers' Association. Since his graduation from the medical department of the University of Buffalo in 1892 he had practised there.

The National Academy of Medicine and the Surgical Society of Rio de Janeiro is compiling a catalogue of all medical publications that have appeared in Brazil within the past hundred years. This catalogue will be distributed at the celebration of the Centenary of Independence which is to be held in 1920. A Congress of Medicine will be held at the same time in Rio de Janeiro under the direction of Professor Fernando Magalhaes, president of the Medical and Surgical Association.

UNIVERSITY AND EDUCATIONAL NEWS

By the terms of the will of Dr. Henry K. Oliver, Harvard University receives funds for a department of hygiene.

The French minister of public instruction has introduced in parliament a bill covering an appropriation of 12,126,000 francs for the benefit of the universities, to be used in the

construction of new buildings, for repairs to old buildings, and for the installing of scientific equipment. The minister of public instruction also requests 900,000 francs to complete the construction work at the Institute of Applied Chemistry; 5,243,000 francs for the extension of the work of the departments of chemistry; 800,000 francs for the enlargement of the Radium Institute, and 1,500,000 francs for the construction of a laboratory of physical chemistry.

THE organization of the new department of hygiene and preventive medicine at Cornell University has been completed, the following appointments to the staff having been made: Dr. Haven Emerson, professor of hygiene and preventive medicine, and director of the department; Dr. James Stevenson Allen, assistant professor of hygiene and preventive medicine, and assistant director of the department; Dr. Frank C. Balderry. medical adviser; Drs. J. Ralph Harris, Lawrence B. Chenowith, Richard Kimpton, Claude E. Case and John A. Herring, assistant medical advisers for men and Drs. Margaret D. Baker and Katherine Porter, assistant medical advisers for women.

DR. ELI KENNERLY MARSHALL, JR., Washington, D. C., formerly associate professor of pharmacology in Johns Hopkins University, has been appointed head of the department of pharmacology at Washington University Medical School. Other appointments are A. W. L. Bray, associate in anatomy; Alfred C. Kolls, associate in pharmacology; Edgar Allen, instructor in anatomy and Edward A. Doisy, instructor in biological chemistry.

DR. EMIL GOETSCH, formerly resident surgeon of the Peter Bent Brigham Hospital, Roxbury, Massachusetts, has been appointed head of the surgical department of Long Island College, New York.

PROFESSOR HOWARD E. SIMPSON, associate professor of geology and physiography at the University of North Dakota, has been promoted to a professorship of geographic geology.

MR. B. MOUAT JONES, assistant professor of chemistry in the Imperial College of Science and Technology, London, has been elected to the chair of chemistry in the University College of Wales, Aberystwyth, in succession to Professor Alex. Findlay.

DISCUSSION AND CORRESPONDENCE

A HELIUM SERIES IN THE EXTREME ULTRA-VIOLET

IT has been shown that the helium series first discovered in a terrestrial source by Fowler can be represented by the formula

$$v = 109750\left(\frac{1}{\left(\frac{n_1}{2}\right)^2} - \frac{1}{\left(\frac{n_2}{2}\right)^2}\right);$$

where n_1 has the value of 3 or 4[1]

If n_1 be given the value 2, and n_2 the successive value 3, 4 and 5, lines result at wave-length 1640.1, 1214.9 and 1084.7. My previous investigations of the helium spectrum did not afford much evidence as to the existence of these lines;[2] a recent search, however, has been more successful. With a powerful disruptive discharge in helium, a sharp, fairly strong line appears at 1640.2; no trace of it is found in hydrogen under the same electrical condition and it does not occur in helium when the discharge circuit is free from capacity. Under the same violently disruptive condition the line at 1216, always present in helium and hydrogen, develops a satellite on its more refrangible side, this satellite is not well resolved, but its wave-length appears to be about 1215.1. The region that should be occupied by 1084.7 is obscured by a strong pair at 1085, probably due to an impurity.

Owing to the difficulties of vacuum spectroscopy it is perhaps unwise to claim that the evidence in this case is conclusive. I regard it as very probable, however, that two members of this series in helium have been found in the extreme ultra-violet.

THEODORE LYMAN

HARVARD UNIVERSITY,
October 25, 1919

[1] Evans, *Phil. Mag.*, 29, p. 284, 1915.
Astrophys. Jour., 43, p. 92, 1916.

DOUBLE USE OF THE TERM ACCELERATION

To the Editor of Science: Dr. Hering's letter in the issue of October 24 raises a question of scientific terminology of a kind not altogether unusual. He contends that the term "acceleration" is used in one sense by the engineer, namely, to signify the rate of change of speed; and indiscriminately, in two different senses by the physicist, one of these meanings coinciding with the engineering usage, and the other conflicting with it. This second use of the word is to denote the vector rate of change of another vector, the velocity. As I understand his letter, he proposes that the physicist abandon this second meaning in favor of the first.

Dr. Hering is an eminent engineer, and I leave it to other engineers to question, if they choose, his right to speak for them. I must protest however, against his version of the views of physicists. The term acceleration, in its strict sense, is now used by physicists only with the second of the two above meanings, and then applies, when used without any qualifying word, only to the motion of a point or particle. The word is sometimes used, in order to avoid circumlocutions, to denote merely the scalar magnitude of the vector. The need of a new word to express this second notion, in the manner in which we now customarily distinguish between velocity and speed, has long been felt. This somewhat loose usage is however quite different from the definition recommended by Dr. Hering, which would give it the meaning "tangential component of the acceleration." It would be rash to assert that the term is never used in this sense by physicists, for carelessness of language is hard to avoid, but few would be found to defend the usage.

Dr. Hering chooses as an illustration of the divergents of physicist and engineer:

> . . . the revolution of a fly-wheel at a constant speed, the rim of which to the physicist is being constantly accelerated while to the engineer there is no acceleration, as the speed is constant.
>
> The physicist argues, and quite correctly, that a moving body represents a vector quantity, as it has both speed and direction. The same external force applied to such a moving body will change either the speed or the direction, depending upon the relative directions of that force and of the moving body. But as force is defined as mass $\times$ acceleration, the physicist, apparently forgetting the difference between pure and applied mathematics, methodically divides this force by the mass and calls the quotient acceleration. It simplifies his mathematics.

I have quoted these remarkable sentences at length, because I should not dare to attempt any summarizing paraphrase. Assuming that the physicist is "arguing correctly" when he makes a "moving body represent a vector quantity," the offense seems to consist in "apparently forgetting the difference between pure and applied mathematics." What is this difference? It is that the "pure" mathematics is applicable to dynamical problems, whereas Dr. Hering's "applied" mathematics is not.

The case of the revolving fly-wheel offers no real difficulty either of treatment or of terminology. The "acceleration" of the fly-wheel as a whole is either a term without meaning, or applies to a translatory movement. Any point or particle of the wheel is accelerated toward the axis, from which we infer the existence of a force in this direction acting on the particle. Of the fly-wheel as a whole, we speak of the "angular acceleration," which is zero when the angular speed is constant and the direction of the axis invariable. From the vanishing of this vector we infer, not the absence of an external force, but the absence of an external torque or couple.

Take the case of a falling particle, describing a parabolic trajectory, and compare the two statements:

(a) The acceleration is g, vertically downward.

(b) The acceleration is $g \cos \theta$, where θ is the angle between the velocity and the downward vertical.

The second of these statements is in conformity with engineering usage, if I understand Dr. Hering correctly. The first statement describes the motion in such a way that if we know the velocity at any time we can

find the velocity at any subsequent time, by adding the vector gt vertically downward to the original vector velocity. The second statement assumes, so far as I can see, a knowledge of one of the quantities we need to calculate. I should very much like to see Dr. Hering's "applied" mathematics applied to this simple problem. So far as I can see, though the first statement simplifies the mathematics, the second abolishes it.

Scientific terminology is like a sharp knife used for the dissection of a problem, and unequaled for its intended purpose. It is an odd coincidence that the very number of SCIENCE which contains Dr. Hering's letter contains also an address by Dr. Gray of Edinburgh, in which the sharpness of this particular knife, the term acceleration in its strict sense, is specially noted. Dr. Hering's proposal is as if one should say, "I find your razor good for sharpening pencils, please shave with something else."

Surely the ends, neither of science nor engineering will be furthered by any such change as Dr. Hering recommends. The question is not one of simplified mathematics, but of clearness of thought.

C. M. SPARROW

ROUSS PHYSICAL LABORATORY,
UNIVERSITY OF VIRGINIA,

NOTES ON METEOROLOGY AND CLIMATOLOGY

AEROLOGICAL WORK—WINDS

AFTER the signing of the armistice had liberated much information that had been held as confidential, it became possible to assemble a group of papers on aerological work describing the pilot balloon methods used by the Weather Bureau, Signal Corps, and Navy for observing winds at various levels, and presenting the results of various lines of research.[1] The use of thousands of two-theodolite pilot balloon runs established an empirical formula for the ascensional rate of pilot balloons which tallied remarkably well with the formula derived from theoretical considerations. This formula is

$$V = 71(l/L^{2/3})^{5/8} = 71(l^3/L^2)^{.208},$$

in which V represents velocity, l the actual lifting power of the balloon ("free-lift"), *i. e.*, the weight it will support, and L the total lift (free-lift plus weight of balloon). Surprising as it is, pilot balloons ascend at a nearly constant rate, once they are above the more or less turbulent surface layer of air. Thus, single theodolite observations of angular altitude and azimuth of a balloon once a minute, when used in conjunction with the computed ascensional rate will yield reliable information as to the actual positions of the balloon, and, therefore, of the direction and velocities of the wind at all levels from the surface to the height at which it becomes lost to view. At the Aberdeen Proving Ground, temperatures for computing the densities of the air in the several altitude zones have been obtained by daily airplane ascents to a height of 10,000 feet. The score of pilot balloon stations in the United States east of the Rockies telegraph free-air wind data to the Weather Bureau in Washington twice daily, where they are used not only for aeronautical forecasting, but also as an auxiliary in making surface weather forecasts.

Meteorological kite flights are now being made at six stations daily (except when winds are light) for recording winds, relatively humidities, and temperatures aloft. The results are telegraphed to Washington daily, and later are published in *Monthly Weather Review Supplements,* where they become available for detailed investigation.[2]

The movements of dust, smoke and clouds are useful as well as balloons and kites for determining the movements of the free air. Dustfalls which occasionally occur in the northeastern United States have been traced

[1] *Mo. Weather Rev.*, April, 1919, Vol. 47, pp. 205–231. Separates of these are still available: apply to Chief, U. S. Weather Bureau, Washington, D. C.

[2] See, for instance, V. E. Jakl, "Some observations on temperatures and winds at moderate elevations above the ground," *Mo. Weather Rev.*, June, 1919, pp. 367–373. Separates of these are still available: apply to Chief, U. S. Weather Bureau, Washington, D. C.

back to the arid portions of the southern Great Plains.[3] Observations of forest-fire smoke also give reliable information of air movements over long distances, as in October, 1918, when Minnesota smoke was observed throughout the eastern half of the United States except along the gulf and south Atlantic coasts.[4] Observations on clouds may be complementary to those on pilot balloons, for the usefulness of pilot balloons decreases as the cloudiness increases. How cloud movements may be used in local weather forecasting has been discussed by A. H. Palmer for San Francisco, M. L. Fuller for Peoria, Ill., and H. H. Martin for Columbus, O.[5]

AIRPLANES AND THE WEATHER

An article on the "Effect of winds and other weather conditions on the flight of airplanes"[6] is a rather extensive, though by no means complete, compilation and discussion of aviators' meteorological experiences. To quote from the synopsis:

> The disturbances of the air due to daytime convection are one of the prime sources of bumpiness. Especially on hot summer days do strong, rapidly rising currents of air penetrate to great altitudes and, where encountered, jolt the airplane. Where the cooler air is descending, the effect is similar to that of falling into a "hole." The height to which the effects of surface roughness extend when the wind is blowing depends upon the speed of the surface wind and the height of the obstruction.
>
> In the free air, aviators' observations show how the layers of air flow over one another, the interface sometimes being marked by clouds and sometimes entirely invisible. At such levels are encountered billows or waves, and considerable difficulty is sometimes experienced in flying through such regions. Clouds, rain and fog all contribute to the discomfort and danger of flying.
>
> Perhaps the most interesting are the experiences in the thunderstorms and the up-and-down winds which accompany such storms. As the driving wedge of cold air at the surface advances ahead of the storm, the air into which the storm is moving is forced upward. The maximum turbulence is found in the region of the squall cloud, but the force of the rising air ahead of the storm is sufficient to carry up an airplane considerably, in spite of the efforts of the pilots to keep the nose of the plane down. The dangers from lightning and hail, are also quite as important as those from the capricious winds.

There is an annotated bibliography at the end. This article bound with two on ballooning and with reviews of Y. Henderson's "Physiology of the aviator," and H. Luckeish's "High lights of air travel," may be had on application to the Chief, U. S. Weather Bureau.

Charles F. Brooks

[3] See Winchell and Miller, *Mo. Weather Rev.*, November, 1918, Vol. 46, pp. 502–506.

[4] *Mo. Weather Rev.*, November, 1918, pp. 506–509.

[5] *Mo. Weather Rev.*, September, 1918, pp. 407–413; July, 1919, pp. 473–474, and August, 1919, pp. 567–570. A limited supply of separates is held by each of the authors named: address, "Weather Bureau Office" at cities named.

[6] *Mo. Weather Rev.*, August, 1919, pp. 523–532, 10 figs.

SPECIAL ARTICLES

A PRELIMINARY NOTE ON FOOT-ROT OF CEREALS IN THE NORTHWEST

During the first half of May, 1918, the Station Entomologist was called to Olympia, Wash., to consult with the farmers and county agent concerning an outbreak of aphis on wheat. He found that the aphids were not responsible for the whole trouble and submitted samples of wheat from the unthrifty fields to the station plant pathologist for diagnosis. Subsequently specimens showing the same disease were submitted from this and other localities in western Washington through the county agents of the respective counties.

Among the first lot of plants were some showing lesions at the base of the stem. These lesions were elliptical, light-centered, penetrating the leaf-sheath and the surface of the stem. Plants with these lesions and others with a general blackening of the lower nodes showed death of the roots at the first node, the plant attempting to make good this loss by putting out roots at the second node. In some plants two sets of roots had been successively killed and roots had been put out at the third

node. Affected plants were sickly in growth, yellowish in color and showed little or no stooling.

Later reports, especially from Cowlitz County, showed that the disease was responsible for uneven stand in the field with considerable lodging, the stems breaking over near the surface of the ground. As reported the disease showed no relation to type of soil or system of culture. The disease also appeared on oats and barley but in less severe form and showed more of a general blackening of the base of the stem and death of roots.

The disease was reported from Cowlitz, Snohomish and Thurston counties on wheat with the greatest severity in Thurston county, while it was reported from Cowlitz county as causing most injury to maturing grain. Reports of the disease on barley were received only from Pierce county. On oats the disease occurred in Clarke, Pierce and Snohomish counties. The wheat crop in certain localities of Cowlitz and Thurston counties suffered material injury while no data are at hand to show that the disease caused any material damage to the other cereals.

In 1902 Cordley[1] reported a foot-rot of cereals in Oregon but gave only a brief description of the disease and did not determine the causal organism. The disease he mentions is undoubtedly identical with the disease which appeared during 1918 in western Washington. No other occurrences of the disease in the united States are recorded. The disease is either a newcomer or has escaped general notice up to the present time.

A very careful microscopic study of the fungus found in the stem lesions was made in the attempt to determine the fungus. The mycelium was sterile, dark brown in color, with constrictions at the origin of side branches. The mycelium agreed fairly well with *Rhizoctonia solani* Kuhn., except in the diameter of the hyphæ which were only about half as large. In case of plants showing a very pronounced blackening at the base of the culm it was found that this was due to a very compact surface growth of dark brown hyphæ, approaching in some cases almost to a sclerotial formation.

No fruiting stage of the fungus has as yet been connected with the sterile stage on the base of the culms. Until this is done we can only compare symptoms, and vegetative characters of the fungus with published descriptions of foot-rot diseases of cereals. There seems to be a very close similarity between the disease as it occurs in Washington and the foot-rot of cereals caused by *Ophiobolus graminis* Sacc., as described by McAlpine[2] and others.

Ophiobolus graminis and other foot-rot fungi are known to produce an ascigerous stage on old stubble, so it seems probable that the fungus causing the foot-rot of cereals in western Washington will be found to have a perfect or ascigerous overwintering stage on the stubble of affected plants. There is also a possibility of the disease occurring on the native grasses. It is on these wild hosts that some of the foot-rot fungi are known to be carried through a crop rotation. It has not been possible to make a careful field study for the discovery of the ascigerous stage. In the limited work undertaken a species of *Pleospora* is the only perithecial form that has been found in the old wheat culms. It is not yet possible to say whether the disease in Washington is identical with any of similar European or Australian diseases.

Reports indicate that the disease is already rather widely distributed in western Washinging and Cordley's account of the disease would indicate that it may have been present for a considerable time. Time alone will determine whether the disease will become as serious as the foot-rot diseases of cereals in Europe and Australia have been.

B. F. DANA,
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[1] Cordley, A. B., Ann. Rpt. Ore. Agr. Expt. Sta., 1912, pp. 66–67.

[2] McAlpine, D., "Take-All and White Heads in Wheat," Bul. Dept. Agr. of Victoria, 9: 1–120, 1904.

THE NEW HAVEN MEETING OF THE NATIONAL ACADEMY OF SCIENCES

The sessions of the autumn meeting of the academy were held in the Osborn Zoological Laboratory, Yale University, on November 10 and 11. The program of scientific papers was as follows:

MONDAY, NOVEMBER 10

Morning Session

Four cliff islands in the coral seas: W. M. Davis.

Some new theorems in the dynamics of a particle: Edward Kasner.

The relative physiological efficiency of spectral lights of equal radiant energy content (by invitation): Henry Laurens and Henry D. Hooker.

A study in synthetic paleontology (by invitation): Richard S. Lull.

The adjustment to the barometer of the hæmato-respiratory functions in man (by invitation): Yandell Henderson.

Development of connective tissue in the amphibian embryo (by invitation): George A. Baitsell.

Afternoon Session

A new method for determining the solar constant of radiation: C. G. Abbot.

A kinematic interpretation of electromagnetism (by invitation): Leigh Page.

Defects found in drafted men: Charles B. Davenport and Albert G. Love.

The effect of physical agents on the resistance of mice to cancer (by invitation): James B. Murphy.

Some restorations of extinct vertebrates. The great sponge colonies of the Devonian; their origin, rise and appearance: John M. Clarke.

On the mechanism of fever reduction by drugs (by invitation): Henry G. Barbour and J. B. Herrmann.

The Thompson effect from the point of view of dual electric conductivity: Edwin H. Hall.

TUESDAY, NOVEMBER 11

A statistical method for studying the radiations from radioactive substances and the X-rays (by invitation). Alois F. Kovarik.

Anatomical changes in the respiratory tract associated with acid insufflation (by invitation): M. C. Winternitz.

Experimental pneumonia in monkeys (by invitation): Francis G. Blake.

The extension of the ultra-violet spectrum. The effect upon an atom of the passage of an alpha ray through it: R. A. Millikan.

Leptospira icteroides and yellow fever (by invitation): Hideyo Noguchi.

Calculating ancestral influence in man (by invitation): H. H. Laughlin.

Calcium and magnesium metabolism in certain diseases (by invitation): Frank P. Underhill, James A. Honeij and L. Jean Bogert.

Reconstruction of the skeleton of the sauropod dinosaur Camarasaurus Cope (Morosaurus Marsh): Henry Fairfield Osborn and Charles Craig Mook.

Restoration of camarasaurus and life model (communicated by H. F. Osborn): William K. Gregory.

Plato's Atlantis in paleogeography (communicated by H. F. Osborn): William Diller Matthew.

Afternoon Session

Lethargic encephalitis and poliomyelitis: Simon Flexner.

The history of the coral reefs of Tutuila, Samoa. Biographical notice of Dr. Samuel Hubbard Scudder, 1837–1911 (read by title): A. G. Mayor.

Changes of land and ocean levels (by invitation): R. A. Daly.

On hyperplasia of nerve centers resulting from excessive loading (by invitation): Samuel Randall Detwiler.

Concentration of the water soluble vitamine of yeast: T. B. Osborne.

The manner of infection of the white pine by the blister rust, with demonstrations at the Connecticut Agricultural Experiment Station: (by invitation): G. P. Clinton.

Certain chemical properties of foods and their relation to nutrition, with demonstrations at the Connecticut Agricultural Experiment Station: T. B. Osborne and Lafayette B. Mendel.

Studies upon the life cycles of the bacteria (introduced by Raymond Pearl) (read by title): F. Lohnis.

Lower California and its natural resources (introduced by C. D. Walcott) (read by title): Edward W. Nelson.

A recalculation of the atomic weights (read by title): F. W. Clarke.

Biographical memoir of Richmond Mayo-Smith (read by title): Edwin R. A. Seligman.

Biographical memoir of Samuel Wendell Williston (read by title): R. S. Lull.

Biographical memoir of Charles R. Van Hise (read by title): Thomas Chowder Chamberlin.

WEDNESDAY, NOVEMBER 12

Morning Session

On the embryological basis of human mortality: RAYMOND PEARL.

Jupiter's five attendant planets (by invitation): E. W. BROWN.

Notes on human sex ratio (by invitation): C. C. LITTLE.

Sex intergrades and their peculiar inheritance (by invitation): A. M. BANTA.

The starting of a ship under constant power (by invitation): J. K. WHITTEMORE.

Endomixis in relation to selection in paramecia (by invitation): LORANDE LOSS WOODRUFF.

The activities of the ions of largely ionized substances: ARTHUR A. NOYES and DUNCAN MACINNES.

The basal metabolism of boys from one to thirteen years of age: FRANCIS G. BENEDICT.

AMERICAN MATHEMATICAL SOCIETY

THE two hundred and fifth regular meeting of the society was held at Columbia University on Saturday, October 25, 1919, extending through the usual morning and afternoon sessions. The attendance included forty-nine members.

Vice-president G. D. Birkhoff occupied the chair. The council announced the election of the following persons to membership in the society: Dr. C. C. Camp, University of Illinois; Professor Carl J. Coe, University of Michigan; Dr. Teresa Cohen, Johns Hopkins University; Mr. W. E. Heal, U. S. Bureau of Plant Industry; Dr. C. A. Nelson, University of Kansas; Mr. J. L. Walsh, Harvard University. Four applications for membership were received.

A list of nominations for officers for the coming year was adopted and ordered printed on the official ballot for the annual election. A committee was appointed to audit the treasurer's accounts for the current year. Propositions for establishing a board of custodians for the society's property and for issuing a new catalogue of the library were laid over for action at the annual meeting.

The following papers were read at this meeting:

Motion in a resisting medium: J. K. WHITTEMORE.

A countable collection of mutually exclusive closed point sets with connected sum: ANNA M. MULLIKEN.

New proofs of certain finiteness theorems in the theory of modular covariants: OLIVE C. HAZLETT.

On the convergence of certain classes of series of functions: R. D. CARMICHAEL.

Note on a transformation of series similar to the principle of inversion in the theory of numbers: R. D. CARMICHAEL.

Note on the theory of integral functions of the first class: R. D. CARMICHAEL.

Two linear integral equations with two parameters: ANNA J. PELL.

Note on stable periodic orbits: G. D. BIRKHOFF.

Some problems connected with submarine acoustics: O. D. KELLOGG.

Differential variations in ballistics, with applications to the qualitative properties of the trajectory: T. H. GRONWALL.

Standard density, temperature and pressure of the air aloft: A. A. BENNETT.

The probable error of a small number of rounds: A. A. BENNETT.

The physical bases of ballistic table computations: A. A. BENNETT.

The sign of the distance in analytic geometry: A. A. BENNETT.

Invariants of infinite groups in the plane: E. F. SIMONDS.

The motion of n bodies, under any forces, starting from rest: EDWARD KASNER.

The San Francisco Section met at the University of California on October 25. The annual meeting of the society will be held at Columbia University on December 30–31 and will be followed by that of the Mathematical Association of America on January 1–2. The Chicago and the Southwestern Sections will meet at St. Louis with the American Association for the Advancement of Science.

F. N. COLE,
Secretary

MEETING OF THE COMMITTEE OF POLICY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE committee on policy met at the residence of President Flexner, New York City, on Thursday, November 13, 1919, at 5 P.M. The meeting was called to order by the permanent secretary, who suggested that Mr. Flexner take the chair. Members of the committee present were: Messrs. Flexner, Humphreys, MacDougal, Cattell, Fairchild, Paton, Woodward, Noyes and Howard.

The minutes of the spring meeting were read and approved.

The permanent secretary made a statement re-

garding the error which had been made at the Baltimore meeting in electing three members of the committee in place of Messrs. Ward, Paton and Fairchild; whereas, three members should have been elected in place of Messrs. Cattell, Woodward and Noyes. On motion, Messrs. Cattell, Woodward and Noyes were requested to act as members of the committee, leaving the election of their successors and of the succeeding group until the meeting at St. Louis.

The permanent secretary presented a progress report with regard to plans for the St. Louis meeting and also plans under way for the increase in the membership of the association. He also presented a general statement regarding the condition of his current financial account.

Some discussion ensued, and Mr. Flexner was requested to deliver a popular lecture, complimentary to the citizens of St. Louis, on the evening of Tuesday, December 30.

A committee of three on the permanent secretaryship of the association was appointed, consisting of Messrs. Flexner, Noyes and Cattell.

On motion, it was moved and carried that the committee recommend to the council that the constitution be so amended as to make the annual dues be five dollars and the life membership commutation one hundred dollars. On motion, it was ordered that this amendment be published in a footnote to the new constitution to be published in SCIENCE.

On motion, it was decided to recommend to the council that in view of the increased cost of printing the price of SCIENCE per member be three dollars and further to recommend that the price of SCIENCE to non-members be fixed at six dollars.

On motion, the permanent secretary was directed to send out his bills for the year 1920 this month at the amount of five dollars. It was decided that in the campaign for new members now being carried on, members joining before January 1, 1920, pay the amount of eight dollars for combined entrance fee and dues.

After some discussion, it was decided that the committee approve of any effort to raise money for the new popular journal in the name of the association by the authorized committee of the National Research Council or its agents.

Mr. Cattell presented a progress report for the committee on state and local academies.

The report of the committee on grants was read by the permanent secretary.

Mr. Paton was requested, as chairman, to take up the work of the committee on delegates for the St. Louis meeting.

Dr. Charles E. Caspari was elected as secretary for Section C for the St. Louis meeting on nomination of Dr. Lovelace, chairman of the section.

The application of the American Academy of Medicine for affiliation was referred to a committee consisting of Messrs. Paton, Flexner and the permanent secretary for further report.

A letter from Mr. S. N. D. North, acting secretary of the Carnegie Endowment for International Peace, was read which suggested that the association endeavor to assist the work of the endowment by making an effort to bring about international cooperation between scientific organizations. A committee, consisting of Messrs. Angell, Humphreys and the permanent secretary, was appointed to confer with the Washington office of the endowment on this subject.

A letter from scientific men in El Paso, concerning a southwestern branch of the association was read and discussed. Mr. MacDougal stated that persons interested in this plan were to meet with the association in St. Louis for more intimate discussion of details.

A report of a call by Mr. Bourland, of the Southern Education Society, at the office of the permanent secretary was read. On motion, it was resolved that the committee looks with favor on the effort to increase the interest of the scientific men in the south and requests the permanent secretary to confer further with Mr. Bourland in regard to the plans suggested by the latter.

The committee adjourned at 9.45 P.M., to meet at St. Louis on Sunday, December 28, at the Hotel Statler, probably about dinner time.

L. O. HOWARD,
Permanent Secretary

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